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Mr. Ramsey -

Respiration

On Essay

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Respiration

An Essay

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The intimate connexion which obviously subsists between the due exercise of the function of the lungs & the phenomena of animal life, has always given to the subject which I have chosen, a prominent rank in Physiology; it has constantly risen in importance in proportion as it has been better understood, and there are at present many who believe that the vital principle itself is evolved during respiration -

In the early periods of Physiological speculation this partook largely of the darkness in which other subjects of this nature were involved, & even at the present time, with all the additional light which improved modes of investigation, & the important discoveries in collateral branches of natural science have shed upon it, our knowledge of it is far from having attained that degree of perfection which renders further research superfluous -

Discouraging as the prospect appears to those who are about to attempt what so many have failed in, there are not wanting on the other hand some motives of a contrary tendency independent of those which naturally arise out of the interesting & important nature of the subject -

Each succeeding enquirer may avail himself of the facts & observations of his predecessors & even profit by their errors, and altho' his attempt may also prove unsuccessful, yet by the developement of new facts or by a happy comparison & combination of those already known he may in no small degree contribute to the advancement of science, or to the more perfect knowledge of the subject to which his attention has been more particularly directed;— until at length by successive contributions a system may be established, capable of withstanding the attacks of all future assailants—

The prevailing spirit of the age leaves no cause to apprehend that a false theory, even when upheld by high authority, should operate unfavorably by checking the progress of enquiry.— Men are now engaged in pulling down than in building up.— & there is danger rather, that in their zeal for demolishing the works of their predecessors, the more valuable part of the materials in the accumulation of which so much cost & labor have been expended, should be overwhelmed & lost in the ruins of the fabric —

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It is not my intention to ransack the rubbish of antiquity in order to bring to light, the great mass of hints conjectures & hypothesis relating to respiration which there lie forgotten, & which could now be entirely devoid of interest, except what they might derive from the period in which they originated. Such researches may be left to those who believe that all the beautiful discoveries of the moderns, may be extracted from the obscure hints which lie scattered thro' the works of the ancient Philosophers, and which may now appear to be remotely applicable to those discoveries after they are made, but to which the authors themselves probably attached little meaning or importance. My design is merely to take a cursory view of the present state of the question; — to offer some objections to the prevailing doctrines which have induced me to renounce them — and finally to lay open some views of the subject which have originated altogether with myself altho' I have since found that they have been entertained in part by others.

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Among the many theories with regard to this function which modern times have produced, there are two which owe their origin to the improved state of chemical science, between which Physiologists are at present principally divided — By the one it is maintained that the oxygen gas of the atmosphere during respiration, unites with the blood in the extreme branches of the pulmonary artery which are distributed upon the membrane of the air cells — That this oxygen becoming more & more firmly united with the carbon of the blood during the course of the circulation, at length after performing a revolution thro' the system, assumes the form of carbonic acid & escapes into the lungs in the gaseous state. According to the other the blood returning from the extreme parts of the body highly charged with carbon, delivers its deleterious load to the oxygen in the air cells & becomes again fitted to perform the offices of animation & nutrition. Several modifications of these have at different times met with their advocates; but as they all consider the essential part of the function to-

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consist, in the one case, in the absorption of oxygen into the blood, & in the other in the elimination of carbon from it, & as my objections be principally against these two fundamental propositions, I think it unnecessary, particularly to notice them.—

The first of these positions seems to derive its support for the most part from the following considerations—

1st The diminution in bulk which the air in the lungs, according to the experiments of some, has appeared to sustain, & which upon examination seemed to arise from the loss of oxygen—

2dly The experiments of Priestly & others in which oxygen was separated from arterial blood, & those of Davy in which it was driven off by heat together with carbonic acid gas.

3dly From the fact established by Bichat & others, that during violent inflation of the lungs air passes into the vessels & might be seen to issue out with the blood on opening one of the larger arteries, & hence that a direct communication exists between the air cells & the vessels—

4th That a portion of oxygen gas may be artificially introduced into the vessels without inconvenience to the animal --

5th That air has been found in the vessels after death -

That the change of color in the blood from black to florid red is owing to its union with oxygen, is thought to be proved, from its assuming the red color when in contact with the gas or other substances that afford it; - from its losing this color when the oxygen is removed or another gas which does not contain it is substituted; - from the color being always proportionate to the disappearance of the gas - This universal dependence of the blood for its change of color upon the presence of oxygen, is supposed to be an additional proof of the absorption of the gas - & one part of the theory is thus made to lend its aid in support of another. The whole theory is thought by its advocates to be conclusively established by the ease with which it accounts for the general phenomena of animal heat - But whatever degree of harmony & beauty it may derive from this consideration, its truth must depend upon the evidence by which

the absorption of oxygen is upheld.

The very varying state of respiration renders it extremely difficult to ascertain whether any change takes place in the bulk of the respired air. A great variety of experiments have however been instituted upon man & other animals in order to determine this point. From some of these experiments it would appear that the air suffers a slight diminution in its passage thro' the lungs, whilst others exhibit no such loss of bulk. The degree of credit to be attached to these different results must depend upon the manner in which the experiments were conducted, & the agreement of the conclusions deduced from them with collateral facts. The experiments of Goodwyn in which there appeared a diminution of from $\frac{1}{50}$ to $\frac{1}{60}$ of the original bulk, were made in the manner proposed by Lavoisier in order to ascertain the changes which the air undergoes. A certain portion of atmospheric air was once inspired & expired, & the above loss of bulk was observed.

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But it is clear that it can never be ascertained from our sensations which in this case must have been relied on, that the lungs contain the same quantity of air before & after the experiment, & the evidence derived from it cannot therefore be deemed sufficient to establish the point in question — Others have endeavored to avoid this cause of error in some measure by breathing a considerable quantity of air a number of times; so that a small difference in the capacity of the lungs at the beginning & end of the experiment, may cause but little in the whole — But by this mode another source of fallacy arises — air thus frequently respired must become constantly more & more deteriorated & the quantity necessary to support the function will be encreased in proportion to the encreased deterioration, & the lungs will consequently contain more of this air the longer the experiment is continued, until it becomes totally unfit for respiration —

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The experiments of Messrs. Allen & Pepys which were conducted in such a manner as to avoid both their sources of error, exhibited little or no loss of bulk in the air expired, but the oxygen gas which disappeared was replaced by a volume of carbonic acid nearly or exactly equal -

The same discrepancy in the results has appeared in attempts to ascertain the changes which the air undergoes, by confining the smaller of the warm-blooded animals in closed vessels - In some of these experiments in which the animals were placed in receivers inverted over water, a considerable loss of volume was observed; but as carbonic acid gas is absorbed by water, it is more than probable that the diminution was owing to this cause - In those of Priestley & Crawford in which mercury was substituted for water, there was no perceptible diminution -

It may perhaps be urged that altho' it be allowed that no change of volume takes place in the expired air, this concession is not incompatible with the proposed theory of oxygenation; for the oxygen

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gas absorbed may have its place supplied by that which has passed through the system & escaped in the form of carbonic acid. But according to this theory the extrication of carbonic acid should continue, after the supply of oxygen is cut off until the blood has performed a complete revolution through the system & parted with that which it must have previously contained. In the respiration of hydrogen gas however, which may be continued for some time, no such evolution of carbonic acid takes place — that only is expelled from the lungs which they contained at the first inhalation of the hydrogen.

The experiments of Priestley prove what is not denied viz that arterial blood contains oxygen, but are far from making it appear that this oxygen is derived immediately from the air in the lungs or that it imparts to the blood its peculiar animating power. Much less can any such conclusion be drawn from that of Davy in which a portion of oxygen gas was driven off from arterial blood by heat.

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An experiment of Bichat has been appealed to with much confidence, as affording strong grounds for believing the passage of air into the vessels — He cut the trachea of a dog so as to adapt to it a stop-cock, & with a syringe he forced into the lungs a quantity of air greater than they contain in an ordinary inspiration & confined it there by turning the cock — The animal immediately became agitated, struggled & made violent efforts to respire — On opening one of the arteries most near from the heart, the blood issued out mixed with bubbles of air — When hydrogen gas was employed, it might be inflamed as it came from the vessel — But it is impossible to be certain as the author himself observes, that no laceration took place in the air cells — Some it appears highly probable that the air thus confined, being compressed by the animal's violent efforts to respire, would force itself a passage thro' the delicate membrane of the air cells into the vessels — This idea is I think corroborated by the fact that when the lungs of an animal, taken from it immediately after death, are inflated with some degree of force an emphysematous state of the organ is often the consequence, which could not take place without laceration

* This consideration also entirely 'I think' sets aside the necessity of calling in the aid of the nervous influence to effect the union between the oxygen & the blood. Experiments of Goodwyn & Prichard similar to those of M. Dupuytren upon which such an opinion was founded, were nevertheless attended with directly contrary results - viz that when the nerves which establish the connexion between the brain & lungs are tied or divided there is no interruption of the chemical but only of the mechanical phenomena of respiration from a paralysis of some of the muscles subservient to this part of the function. If this should be deemed insufficient, the experiments of Brodie & Legallois & the fact that when the lungs are removed from an animal & inflated, the blood is changed from black to red, must be considered as absolutely conclusive -

It is now altogether unnecessary to suppose the existence of any such communication either by means of absorbent or otherwise; for it is perfectly familiar to every one at all conversant with the subject that the blood is acted on by the air thro' the dense coat of a bladder although utterly impervious to a gas - at in which no power analogous to absorption could possibly exist -

It was at first considered as a strong objection to the theory of oxygenations as being entirely at variance with a known law of chemical affinity - that the ~~blood~~ gas should be attracted thro' the membrane by which it is separated from the blood in the lungs. This was however thought to be completely obviated by an experiment of Priestley just alluded to - But in order that this experiment should possess all the weight which later supporters of the doctrine have attached to it, it must be conceded that the change of color in the blood is owing to the absorption of oxygen; a conception which involves the subject of dispute itself - It is necessary first to prove that oxygen is absorbed, before the change of color can be admitted to depend upon it -

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The original difficulty therefore still recurs & has never yet been satisfactorily removed — on the contrary by pursuing the course pointed out by this experiment more has been proved than was originally intended & the objection has constantly increased in force as the investigation has been further pursued — Dr Priestley himself observed that a layer of serum formed no impediment to this supposed transmission of oxygen & later experimenters have found that it acts also through albumen & other animal fluids, whilst its action entirely ceases when a thin layer of water, oil, a solution of gum arabic is interposed, or in general any fluid which produces little or no change on the air — — In a late work on the changes induced in the air by the germination of seeds, the vegetation of plants & the respiration of animals; there are two experiments detailed relating to this part of the subject, which I think are almost alone sufficient to set this point at rest — a small bladder filled with venous blood was suspended in a glass jar containing atmospheric air, inverted over mercury the capacity

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of which had been previously ascertained: the blood soon became reddened; & on removing it at the expiration of two days, it was found that the included air had lost the whole of its oxygen & that an exactly equal volume of carbonic acid had been formed. Now as it had been before proved that no carbonic acid was formed where no oxygen existed, the gas which disappeared must have been wholly employed in the formation of the carbonic acid in the above experiment and none therefore could have entered the blood. When empty bladders were used, or simple water substituted for the blood, the oxygen gas was found to be equally changed into carbonic acid: and as the moistened bladder thus appears to be quite a sufficient source for the carbone, it would be in direct opposition to one of the fundamental principles of philosophising to derive it from any other — Hence I think the change of color in the blood from black to florid red, can no longer be supposed to depend either upon the absorption of oxygen or the extrication of carbone —

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In reflecting on the readiness with which the blood is acted on through the thick coats of a bladder, it occurred to me that perhaps some light might be thrown on the subject by trying whether this mysterious influence would not be transmitted through more still more dense, and totally impervious to either of those substances, of which the union of the one, or the separation of the other, has generally been resorted to account for the phenomena observed in respiration - With this view I filled a small glass vessel full of venous blood drawn fresh from the arm & covered it over with a piece of sheet lead exactly equal in circumference to the top of the glass. taking care to avoid any space for air between the surface of the fluid & the metal - In ordinary circumstances the change of color in the blood seems obviously to depend upon the conversion of oxygen into carbonic acid - In order therefore to afford a source for carbon & still more completely to prevent the contact of the air with the blood, I tied firmly over the top of the vessel a piece of bladder moistened with serum - On removing the covering at the expiration of twelve hours, I found that a very evident change

With the slender means of investigation which I possess, it can scarcely be expected that I should be able to offer a satisfactory solution of so difficult a question. To accomplish this would require a course of experiments conducted with all the advantages of time & means, & a scrupulous regard to the strictest principles of philosophizing. All that I propose to attempt is, to offer some views of the subject which as far as I know, have hitherto met with very little attention from Physiologists, with a hope that they may lead to more correct ideas with regard to the nature of the function, than have hitherto been generally obtained.

The author before referred to, Ellis on Respiration after a great variety of experiments & comparing their results with those of other naturalists, finally adopts this general conclusion. that during the germination of seeds, the vegitation of plants & the respiration of animals the oxygen gas of the atmosphere is converted into an exactly equal volume of carbonic acid. The work throughout proceeds upon the fundamental basis of observation & experiment & affords a most admir

* I have since found that when a glass plate is substituted for the leaden one in the above experiment – no change whatever is perceptible –

rable exemplification of the principles of the Novum Organum. It would lead me much beyond my purpose to attempt to give even a summary of the evidence upon which the general conclusion rests; for this I must refer to the work itself. It is however so full & satisfactory, that I feel not the least hesitation in relying upon the result, as it regards respiration. Since then the conversion of oxygen into carbonic acid is the only essential change in the inspired air, it is to this that we must look for a solution of the difficulty.

The strong analogy long ago observed between the oxidation of the metals & this slow combustion of carbon, induced me to suspect that it might hold in some other respects. It is a point now well established & acknowledged I believe on all hands, that in the galvanic battery the electric fluid is disturbed & extricated, primarily by the union of oxygen with the metal. Perhaps then a similar disturbance may take place in the formation of car

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bonic acid - This idea is I think rendered probable by the experiments of Davy from which it would seem that in all cases of chemical action the electrical capacity of the resulting compound like its specific calorie is seldom perhaps more, the mean of that of the constituents taken separately and hence that the fluid is nearly disturbed & either absorbed or extricated at the moment of union - The older chemists indeed held it to be one of the component parts of oxygen gas & that it was given off in every case of combustion, and altho this idea is not so much insisted on at present it is not altogether destitute of support - It forms no objection to it that the fluid is not accumulated & rendered sensible during an ordinary case of combustion - since the burning body is constantly creating for itself conductors all around it by means of which the fluid passes off - for even the most perfect non conductors lose this property when heated -

I find it lately stated that a very good galvanic battery for temporary purposes may be constructed of sh-

ces of beet & carrot cut transversely and arranged alternately in the form of a common pile. it is said that 2 or 300 pairs of these vegetable plates communicate a considerable shock. In what way can the electric fluid be disturbed in this case? The vegetably are used before any thing like decomposition is about to take place, & it can therefore scarcely be referred to any chemical change going on in the vegetable substance itself independent of the action of the air. But it appears from actual experiment that these substances are constantly forming carbonic acid when exposed to the air, by the union of their carbonaceous matter with its oxygen. We are then I think, considering the very striking analogy between this apparatus & the usual one of the metals, almost warranted in the conclusion that the electricity is disturbed & made sensible by the cause last mentioned. There is an experiment of Humboldt in his researches into the nature of galvanism which seems clearly susceptible of the same explanation. It is well known that frogs prepared as this usually are for galvanic experiments form the most delicate electrometers that we possess. Humboldt succeeded in exciting contractions in them merely by means of moist animal substances applied to the muscle & nerve. Now Volta has

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shewn satisfactorily that in this experiment the galvanic fluid does not come from the nervous system of the animal as Galvani thought, but from the coatings applied to the nerves & muscles But it has been already shewn that animal substances act upon the air in the same manner as the vegetables before mentioned converting its oxygen into carbonic acid - and this I think seems the most probable source of the electricity evolved in this experiment. It may be said that if the electric fluid is thus separated during respiration & combined with the blood some traces of its existence in this fluid would have been observed and we should find it constantly passing off from the body - accordingly it is stated by Vassali an Italian physiologist that he had proved by experiment that the blood is always positive - he further mentions on the authority of Redi that the expired air has lost its ~~negative state~~ natural electricity - with regard to the other point the same author refers to experiments of his own on cats rats &c which he says prove the escape of the electric fluid from the animal body - indeed it had long ago been

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observed that the body always exhibits a positive state and it would be very easy to collect if necessary a great variety of testimony in proof of it, but perhaps the familiar observation of the escape of the electric fluid from a woolen or silk stocking after being worn in a cold & dry state of the atmosphere, may afford a sufficient illustration of the fact — Connected also as it seems to me with this subject, is an observation which I accidentally made myself, that if while the circulation is going on freely in the hand, it is applied to a surface of venous blood fresh drawn & then immediately with drawn, the point of the hand is left of the bright arterial color — This instantaneous change of color can hardly be referred to the action of the surrounding air for the hand excludes it; or to the abstraction of the oxygen supposed to exist in the arterial blood of the hand, or to the escape of carbone into it — for these explanations are rendered inadmissible by the experiments which I have already detailed — It seems necessary to have recourse to the operation of a fluid far more subtile than either carbone or oxygen to account for it —

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As an obvious consequence of the views which I have thus been endeavoring to render probable, it would follow that venous blood would be changed in color when subjected to the action of the electric fluid. Being about to make experiments to test the truth of this supposition, I accidentally met with a treatise on Galvanism by C. Wilkinson, in which the author attempts to show that respiration is a galvanic operation. He founds this opinion principally on this very effect of the electric fluid which I had anticipated. He also points out a strong analogy between the structure of the lungs & of the electric organs of the torpedo. He offers however no explanation of the manner in which this fluid is separated from the air, & the theory is connected with a supposition which seems scarcely to deserve a better appellation than that of absurd, — that the coloring part o red globules of the blood conveyed by the arteries to their extremities, are not returned by the veins, but are entirely consumed in the nourishment of the system.

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I am aware that altho' the points which I have been contending for be allowed me, they are still insufficient to prove that the change of properties which the blood undergoes in its passage through the lungs, the peculiar animating power which is there imparted to it, depends upon a combination with the electric fluid — a view that the change of color which takes place in the vessels, is the same or owing to the same cause as that which is effected by ~~the~~ electricity in blood separated from the body. To ascertain this would require a series of experiments on living animals, which my situation at present does not permit me to make.

In a subject so important & involved in so much difficulty & obscurity as the one under consideration, every suggestion which affords the least prospect of throwing light upon it, deserves attention; That which I have offered is not I think by any means destitute of probability — at any rate an investigation ~~conducted~~ instituted with such views & conducted with a due regard to the principles which should regulate it, could hardly fail to lead to important results. It would I know be exceedingly difficult, if not

unnecessary experiments, ing and ascertain the electric would be in the abdominal ligature pendent, what is whether blood was really not in evidently the blood the arteries jugular appearance to the this appearance with the into which

impracticable, to attain the object proposed by experiments applied directly to the function in the living animal. Perhaps it might be better done by ascertaining the effects of blood which had undergone the electrical change, upon an organ where they would be immediately sensible; as for instance upon the brain, by tying the arteries which supply it, adapting a syringe to one of the carotids above the ligature, and as soon as the cerebral energy was suspended, injecting blood changed by electricity — somewhat in the way practised by Bichat to determine whether black blood exposed to the action of the oxygen was really converted into arterial. The experiment did not it is true succeed in that case, but this was evidently owing to some admixture of the gas with the blood injected. In the case might be thus varied — the arteries being tied as before, adapt a tube to the jugular vein communicating with a bladder or other apparatus in which the blood might be subjected to the electrical action without exposure to the air this apparatus being connected by another tube with the syringe thro an aperture near its bottom into which a valve opening inwards was fitted; —

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It appears then I think from the facts & observations above detailed -

1st That black blood separated from the body & exposed to the air, is reddened by something which is transmitted through metals & intercepted by glass and which is extricated during the formation of carbonic acid - -

2ndly That its is probable that in the union of carbone & oxygen the electric fluid is evolved -

3rdly That by this fluid black blood is changed to red -

4thly That arterial blood exhibits a positive state of Electricity -

5thly That the electric fluid is constantly passing off from the animal body -

Hence I have been induced to suspect that the changes which the blood undergoes in its passage through the lungs are to be attributed to its union with electricity evolved during the formation of carbonic acid -

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It would be easy for me to expatiate over the wide field for speculation which these views of the subject afford and to apply them in a very plausible manner to the explanation of many of the phenomena of animal life. The evidence by which they are supported would not however warrant such an application — it must therefore be deferred until more ample time and means shall enable me either to establish the theory upon the firm basis of observation & experiment, or compel me to consign it to the fate which so many before it have experienced —

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